Prepared Statement of
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at the
Legislative Hearing on America's Climate Security Act of 2007, S.2191
of the
Committee on Environment and Public Works
United States Senate
Washington, DC
November 8, 2007

Madame Chairman and Members of the Committee:

Thank you for your invitation to participate in today's hearing. I am Anne Smith, and I am a Vice President of CRA International. Starting with my Ph.D. thesis in economics at Stanford University, I have spent the past twenty-five years assessing the most cost-effective ways to design policies for managing environmental risks, including cap-and-trade systems. For the past fifteen years I have focused my attention on the design of policies to address climate change risks, and have prepared many analyses of the economic impact of climate polices. I thank you for the opportunity to share my estimates of the impacts of America's Climate Security Act of 2007 (S.2191) with you. My written and oral testimonies reflect my own research and opinions, and do not represent any positions of my company, CRA International, or its clients.

Net societal costs are an inescapable aspect of an emissions limit via a cap-and-trade program that cannot be eliminated through any allocation formula that may be devised. The potential economic impacts of any new policy should be carefully explored, but particularly so when one expects that the new policy would cause dramatically altered patterns of economic activities and consumer behavior. This is certainly the case for a greenhouse gas policy such as S.2191

I have estimated the costs and economic impacts of S.2191 using a model called MRN-NEEM that I and my colleagues at CRA International have developed over the past two decades specifically to provide a credible and state-of-the-art ability to assess greenhouse gas emissions control policies. I will summarize the results of these analyses in my testimony, and also discuss some other issues with how S.2191 would affect the economy that are not directly addressed in the model analyses.

OVERVIEW OF ECONOMIC IMPACT MODEL

Detailed documentation of the MRN-NEEM model is available on CRA's website.[1] In brief, this model is a "general equilibrium" model of the US economy. This means that it tracks every dollar that is spent in order to reduce emissions through the economy, accounting for economic gains in those sectors that provide the goods and services that result in emissions reductions, as well as economic costs to those who must incur these added expenditures, and to those sectors that lose demand as a result of the policy. The model also accounts for any changes in the distribution of wealth that result from the combined impact of emissions control spending and the disposition of the

[1] http://www.crai.com/pubs/pub_7748.pdf

wealth associated with newly created allowances. The results of a model run thus reflect the *net* impact to the U.S. economy after all of the winners and losers under a proposed policy have been accounted for. It is these net costs that should be compared to the changes in climate-related risks expected of the policy.

The model assumes that implementation of an emissions cap will occur in a least-cost fashion with fully-functional, competitive product and allowance markets. The only limits imposed on the efficiency of a cap-and-trade market are those that are directly specified in a Bill, such as when some sectors are not covered by the proposed cap scheme.[2] Leakage of some economic activities outside of the U.S. is also estimated for sectors that face competitors in other countries that do not have their own emissions caps.

Additionally, MRN-NEEM assumes all businesses and consumers have "perfect foresight" of future allowance prices and policy requirements. This means that the model does not include any costs due to uncertainty and "surprises" that will probably also be associated with compliance with a new policy. It captures only a long-run equilibrium in all of the markets, and thus does not include any of the costs of an overly rapid shift in markets due to imposition of a new policy. The potential disruptiveness of the transition to the new equilibrium, however, can be assessed by considering the rate of change in key markets observable in the model results.

MRN-NEEM represents the US economy in 9 geographic regions and 10 business sectors from 2010 through 2050. Table 1 lists the 10 sectors. The model also includes household emissions (including from personal automobile use) and government spending. The electric sector – a very central playing in the emissions control effort – is represented in exceptional detail. Electricity markets are divided into 29 regions interconnected by limited transmission capabilities. Every generating unit in the US is represented in the model, with its current emissions control equipment, and retrofit opportunities. Generating emissions of SO_2, NO_x and Hg (and their associated caps) are also included. Use of existing power plants is determined by their ability to serve electricity load cost-effectively, and the model retires plants that can no longer do this as emissions caps come into effect. The model contains substantial detail on new generating technologies that can be built, including all of the major forms of renewables generation, new nuclear power, and an ability in the future to add (or retrofit) carbon capture and storage onto advanced coal-based generating units.

Table 1: Business Sector Disaggregation Used in MRN-NEEM Model for Analysis S.2191

Energy Sectors	Non-Energy Sectors
Coal extraction	Agriculture
Oil and gas extraction	Energy-intensive sectors
Oil refining/distribution	Manufacturing
Gas distribution	Transportation services
Electricity generation	Services

[2] Placing sectors that are not covered by the proposed cap into the offsets category still limits the program's efficiency.

SUMMARY OF ESTIMATES OF THE ECONOMIC IMPACTS OF S.2191

Key Assumptions

Using the MRN-NEEM model, I and my colleagues have prepared a number of different simulations of the economic impact of the emissions cap-and-trade program of S.2191. These simulations (or "scenarios") differ in their input assumptions, thus providing a *range* of estimates of the impact of the Bill that I summarize in my testimony below. The range reflects a variety of assumptions about the following key inputs:

- *The precise numerical level of the cap.* This is the most important cause of the ranges that I will report. Characterizations of S.2191 imply that the cap in 2012 would be set at 2005 emissions levels. However, the Bill itself states a numerical cap of million metric tons of CO_2 in 2012 that is about 10% lower than the official US Greenhouse Gas Inventory's 2005 emissions reported for the sources that S.2191's cap would cover. Lacking any information to resolve this discrepancy, I present results that have applied a cap at the numerical limits stated in Section 1201(D) of S.2191, and also at the higher level that we find reported in the US Inventory. As in any cap-and-trade program, the stringency of the cap determines the cost of the policy. The scenarios that were run using the more stringent caps stated in S.2191 are generally those that define the more severe economic impacts shown in the ranges that I report below. Similarly, the scenarios that were run using the less stringent cap levels (based on the data published in the inventory for the covered sectors) generally define the less severe economic impacts in the ranges that I report below.
- *Timing for availability of advanced, low-carbon technologies.* All scenarios showed exceptional reliance on advanced, low-carbon technologies that are not presently commercially available, particularly coal-based generation that uses carbon capture and sequestration (CCS) and zero-carbon liquid fuels, such as could be provided by commercialization of cellulosic ethanol. Scenarios reported here reflect a wide range of different assumptions about the date of availability and rate of potential construction of CCS technology, although even the most "pessimistic" of the assumptions used did allow a very large amount of the technology to be introduced, as I will explain below.
- *Cost and effectiveness of advanced, low-carbon technologies, and rate of cost improvement*. Although cost estimates are available for technologies that will one day come into the market place, these estimates are viewed as quite uncertain. They will also change over time, even if a current estimate is a sound one for a given point in time. Our scenarios reflect a variety of the current estimates of technology costs and different rates of improvement over time in those costs.
- *Rate of growth in electricity demand.* The rate of increase in energy demand as the economy grows (i.e., the energy-intensity of the economy) also contributes to the degree of effort that it will take to meet a future cap of any particular level. Our scenarios contain a range of base case electricity load growth assumptions, generally defined by projections of the National Electricity Reliability Council (NERC) which monitors the sufficiency of US electricity supplies and by the projections of the Energy Information Administration (EIA) in its *Annual Energy Outlook 2007.*

- *Natural gas prices.* Long-term natural gas prices forecasts are very uncertain, but can have a significant effect on the cost of achieving different CO_2 levels. Our scenarios rely on the reference cases of the EIA's *Annual Energy Outlook*s (both 2006 and 2007) through 2030, where that forecast ends. After that, our scenarios vary in whether they assume gas prices would continue to increase over time, or would remain flat (in real dollars) after 2030.

- *Quantity of offsets allowed*. S.2191 would allow a limited number of offsets to be used in meeting its caps. There is some uncertainty in interpreting its provisions regarding how much flexibility these provisions would provide to use a variety of sources and types of offsets. Our scenarios use offsets limits that range from 15% to 30%, reflecting different views on how much could be obtained through international channels under Title II.E.

- *Quantity of new nuclear capacity that may be built.* All of our scenarios allow new nuclear generation to be built after 2015, and allow the existing fleet of capacity to remain through 2050. The scenarios allow a maximum of 85 to 130 GW of new nuclear capacity to be added by 2050 (depending on the scenario), and they all impose limits on how fast these can be built. These quantities are approximately equal to the amount of nuclear capacity already in place in the US, and so our analyses essentially double US nuclear capacity between now and 2050.

- *Degree of emissions banking that will be adopted.* S.2191 allows unlimited banking. However, our analyses reveal that the incentives to bank in the period 2012-2020 are driven by expectations of very rapid allowance price escalation in much later years (e.g., in 2035-2050). It is debatable whether companies will engage in large amounts of banking to optimize costs over such a long period when they imply such substantial added near-term cost. Allowing the model to simulate such banking reduces total present value of costs, but it increases the impacts in the first years of the policy while it reduces the later year impacts by even more. Our scenarios include cases with and without banking behavior.

All of our scenarios have substantial quantities of new renewables, available immediately. The maximal quantity of different types of renewables varies by region, based on publicly available information on these resources. Our scenarios do not vary the assumptions about these technologies.

S.2191 allows some constrained amounts of borrowing. We reviewed our scenario results for whether borrowing would occur. We find that if long-term incentives are fully considered, there is actually an incentive even in the first years of the policy to *bank* rather than borrow. If a more myopic view is assumed, there would be a very slight incentive to borrow in the first few years of the period, *if there were no penalty for doing so.*[3] Given the financial penalties that S.2191 would impose, and the limits to borrowing, we do not believe borrowing behavior would affect our cost estimates, and we did not make an effort to model it directly. We also find it difficult to see how borrowing could proceed, given that S.2191 intend to place allowances into accounts only on a year to year basis. Without having possession of one's future allocations of allowances, borrowing would be a complex process, if possible at all.

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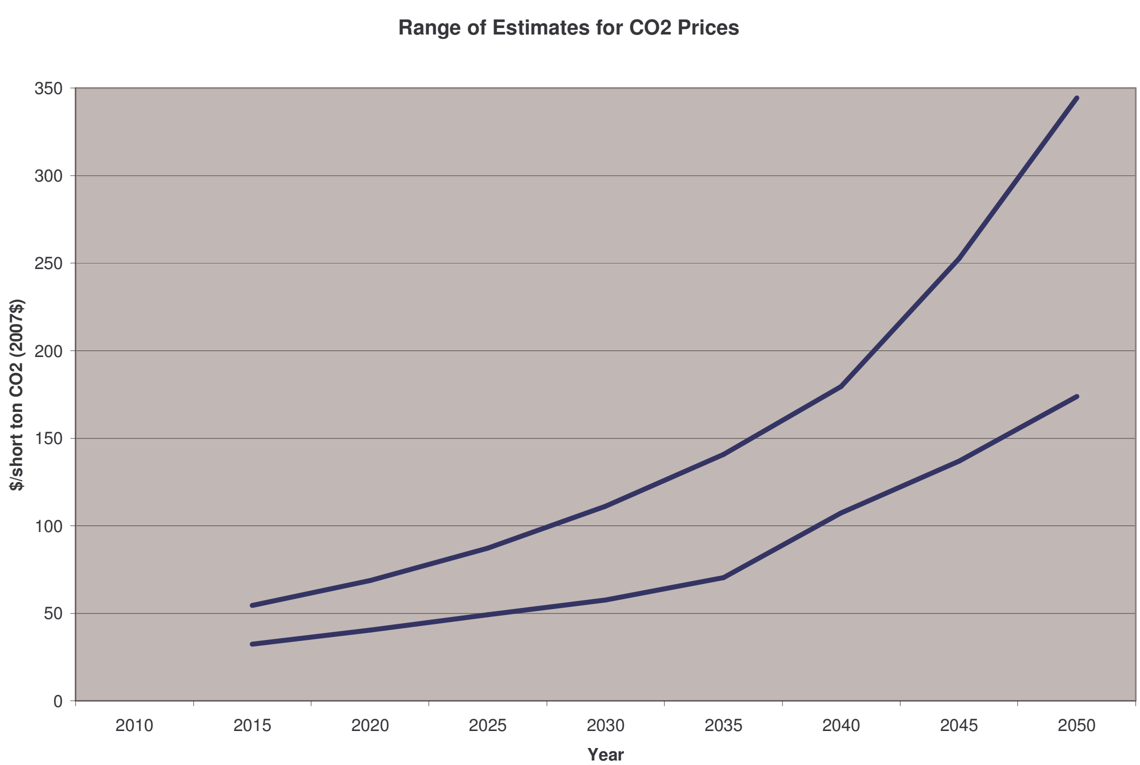
[3] That is, allowance prices in the initial periods when we turn off banking rise at about 1% to 4% in real terms into the next 5 years. (In later years prices escalate by over 10% per year, implying a great desire to have built up a bank before that time period arises.) With a real discount rate of 5%, one might wish to borrow slightly from the next time period. However, a strong incentive to borrow would only occur if we were to see allowance prices falling in real terms, and we have not observed that outcome. The decision to tighten the cap in 2020 between the draft and final version of S.2191 weakened the potential incentives to borrow at the outset.

Ranges of Estimated Macroeconomic Impacts

Figure 1 presents the range of estimates of the marginal costs of meeting the S.2191 caps observed in the scenarios we have simulated. In this figure (and all that follow in my testimony), the two lines presented reflect the upper and lower bounds of our results.[4] Individual scenarios' results fall inside the ranges presented, with the exception of the single highest and lowest estimate for each year.

The estimates shown in Figure 1 are the marginal costs of control, stated as dollars per short ton of $CO_{2\text{-}e}$. This model output is commonly described as the allowance "price." However, it is important to note (as will be discussed in a later part of this testimony) that actual market prices of allowances are highly volatile, and rarely reflect their long-run equilibrium level. The results presented here indicate the long-run equilibrium prices levels that may be expected under various different assumptions. The stringency of the cap itself is the greatest driver of these results, with higher prices associated with tighter caps. As noted above, just the uncertainty in what the actual numerical level of the cap may be under S.2191 determines where in the range shown in Figure 1 one might expect to be.

Figure 1. Range of Estimates of Marginal Costs of Meeting S.2191 Caps (Allowance "Prices")



As Figure 1 reveals, marginal costs of controls are projected to be in the range of $32 to $55 per short ton of CO_2 by 2015. Although our projections show prices rising to levels that are much higher after 2015, even the 2015 prices are "high" in an absolute sense. The 2015 projected price levels, if

[4] These are not "confidence intervals" but true minimum and maximum values over the set of scenarios we have run. We also note that there was nothing in the construction of our scenarios intended to capture a probability distribution of any sort. That would require much more work than has been accomplished.

injected into the economy in a period of only a few years, would be disruptive to the economy, and cause a painful transition. Our modeling effort considers only long-run equilibrium outcomes, and does not in any way capture short-term transitional costs, that can be much larger. It is my assessment, looking at these initial prices levels, that the first few years of a cap such as prescribed in S.2191 would be a time of substantial market turmoil that is not reflected in any of the impact estimates that I report next.

MRN-NEEM is a model that optimizes economic welfare. Thus, the change in economic welfare that will result from a policy is its key output, and it is stated as a present value over the full time period analyzed, which is 2010-2050 in the current case. Our scenarios imply that S.2191 would decrease US average economic welfare by 1.1% to 1.7%. This impact varies by region, and the degree of regional impact can be varied by the formulas for allocating the allowances. Our analyses included a representation of the allocation formulas in the draft version of S.2191 (i.e., the August "Annotated Table of Contents"). Using that set of allocations and formulas for recycling of auction revenues, we find that New York, New England states, and California would experience welfare impacts substantially less than the US average, while regions heavily reliant on fossil fuel energy sources would face impacts somewhat greater than the US average.

Figure 2 presents these economic welfare impacts restated in terms of changes in the annual value of all goods and services consumed by the average US household. This measure is very similar to an estimate of the change in real disposable income. Our scenarios imply that real annual spending per household would be reduced by an average of $800 to $1300 in 2015. If the percentage consumption impacts projected for each future year were to be stated in terms of current real spending power (we use 2010 spending as the proxy for "current" here), these spending impacts would increase to levels of $1500 to over $2500 by the end of our modeled time period, 2050. The costs shown in Figure 2 reflect the net impact on consumption due to more than just higher household energy bills. These costs also capture the net effect of increased costs of all goods and services, which require energy to produce.

Another commonly used metric of economic impact is gross domestic product (GDP). This declines as consumers demand fewer goods and services, and it also declines if US businesses close down due to competition from international suppliers. Offsetting these declines are increases as new investments are made in advanced energy technologies. Our scenarios find a net reduction in 2015 GDP of 1.0% to 1.6% relative to the GDP that would occur but for S.2191. The impact rises to the range of 2% to 2.5% thereafter. Figure 3 shows the associated dollar amount by which GDP would be reduced in each year, stated in real 2007 dollars. (Inflation will make the dollar amounts larger over time.) GDP would be lower in 2015 by about $160 billion to $250 billion. Eventually, the annual loss in GDP would increase to the range of $800 billion to $1 trillion (stated in real, 2007 dollars). (To provide some context, current annual outlays for Social Security are about $600 billion.)

Naturally, with reductions in GDP come reductions in real wages and job losses. We have estimated 1.2 million to 2.3 million *net* job losses by 2015 over our set of scenarios. By 2020, our scenarios project between 1.5 million and 3.4 million net job losses. There is a substantial implied increase in jobs associated with "green" businesses (e.g., to produce renewable generation technologies), but even accounting for these there is a projected net loss in jobs due to the generalized macroeconomic impacts of the Bill.

Figure 2. Impacts to Average US Household's Annual Consumption (in terms of current spending)

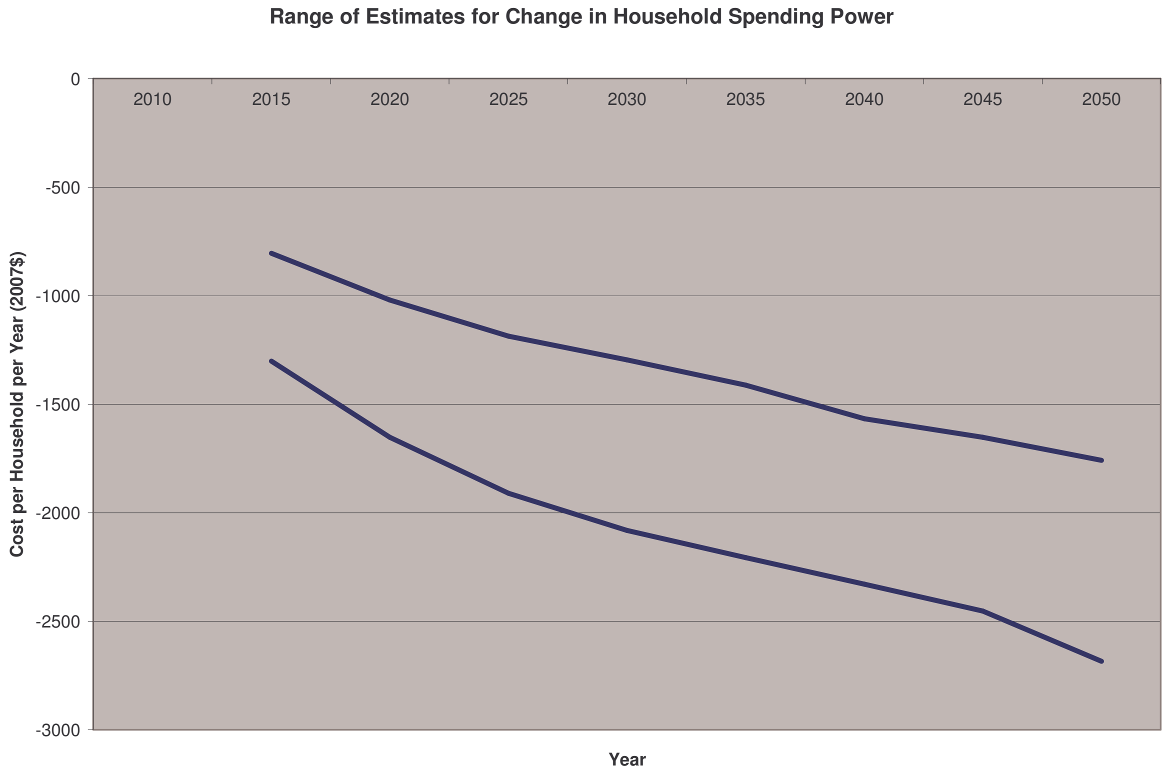
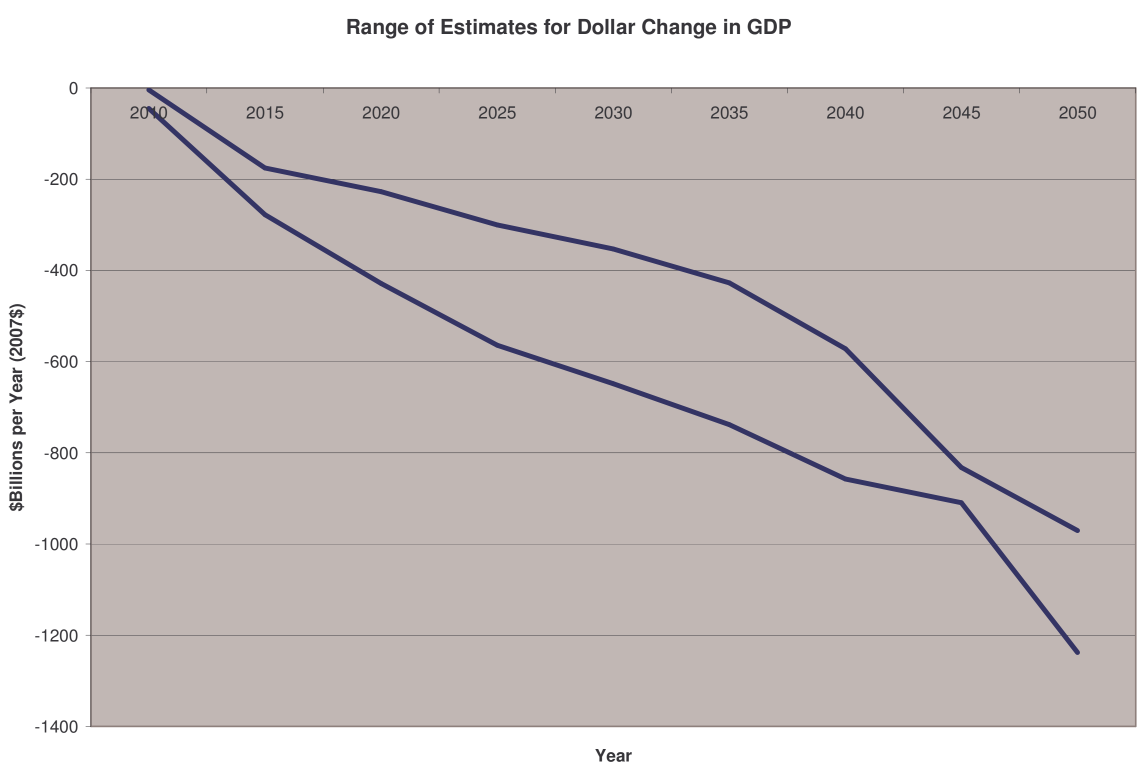


Figure 3. Change in GDP by Year Compared to No Carbon Cap ("BAU")



Ranges of Estimated Energy Market Impacts

Impacts I have presented thus far reflect the economy-wide, or "macroeconomic" impacts that are projected to occur when a cap such as that of S.2191 is imposed. Underlying those impacts are significant alterations to the way that energy needs are met. I will now turn to some of the changes in fuels and electricity markets that drive the macroeconomic impacts described above.

In the near term, the only way to make large reductions in emissions without reducing energy use is to shift from coal-fired generation to natural-gas fired generation of electricity. As I will show later, the electricity sector is projected to make a very large increase in natural gas demand (i.e., up to 4 quadrillion Btus by 2015-2020). Somewhat offsetting this very large increase, our scenarios also project a decrease in natural gas demand from other productive sectors covered by the S.2191 cap.[5] We project a *net* change in US natural gas demand of up to 3 quadrillion Btus. (For context, current gas consumption in the US is about 20 to 21 quadrillion Btus, of which 5 to 6 quadrillion Btus are consumed by electricity generators.)

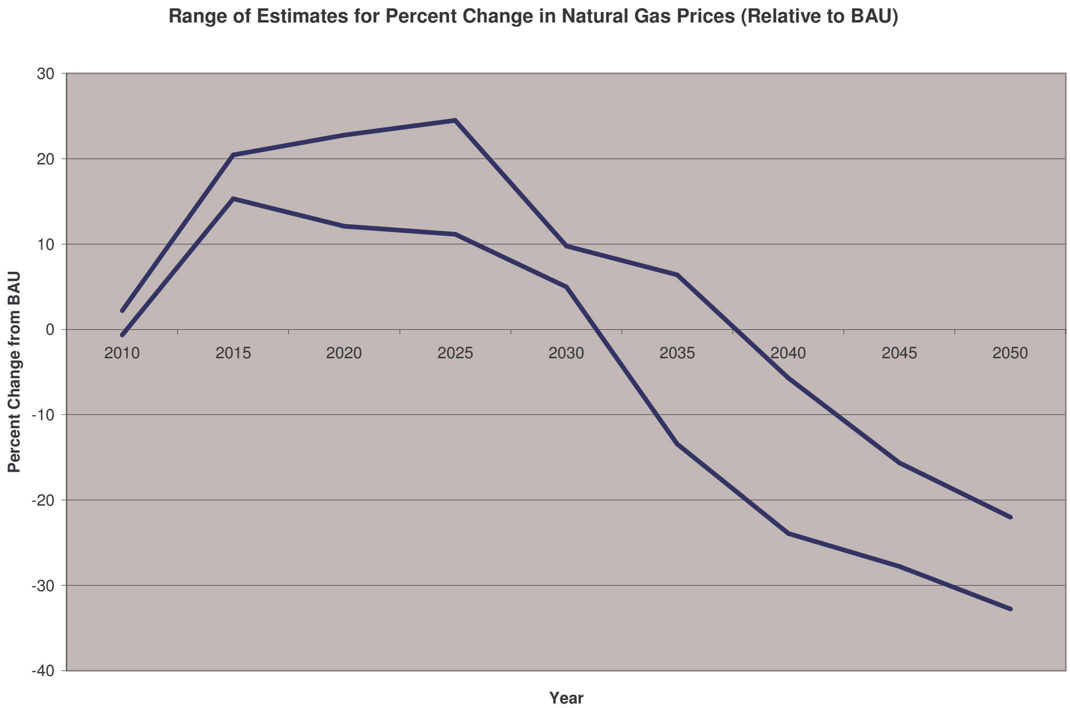
Naturally, increases in gas demand will translate into higher natural gas prices. Figure 4 presents the percentage changes in projected natural gas prices that our analysis estimates would occur *under long-run equilibrium conditions.* Even with a long-run equilibrium view, we project gas price increases of 15% to 20% by 2015, and staying high through 2030. As I mentioned earlier, however, sudden shifts in demand such as those projected by 2015 would cause significant market turmoil and much higher price spikes until a new long-run equilibrium of gas supply can be established.

Figure 4 also shows that in later years (i.e., after 2030), natural gas demand actually starts to fall relative to currently projected future levels. This occurs as more advanced technologies are projected to become more widely available. Natural gas may emit less CO_2 than current coal-fired generation, but it does still emit substantial amounts of CO_2. In the longer run, as the cap tightens further, natural gas becomes the highest-emitting source of energy and also starts to face declines in demand. This suggests that near-term caps that can only be met through a disruptive shift to greater use of natural gas may be a more costly policy than necessary to achieve large cumulative, long-run reductions in greenhouse gas emissions.

Our analyses of S.2191 account for all sources of greenhouse gas emissions (including the non-CO_2 greenhouse gases) on a nearly economy-wide basis. A substantial share of the long-run reduction is due to major shifts in all parts of the economy, including a transformation of the way that vehicles are fueled. However, the majority of the emissions reductions in the near-term come from changes in electricity generation emissions. These emissions account for about 34% of total greenhouse gas emissions today, but they are projected to contribute well over 50% of the emissions reductions under S.2191 prior to 2030. I will therefore describe now the types of electricity sector changes that our analyses are projecting will occur in order to achieve the reductions under S.2191.

[5] All of the scenarios summarized in my testimony exempted household and commercial uses of natural gas, as they were prepared before the mark up of S.2191 in which these sources became covered by the cap as well.

Figure 4. Changes in Projected Long-Run Equilibrium Prices of Natural Gas



Electricity-related emissions changes are projected to come from a mixture of use of different fuels, use of different technologies, and reduction in electricity demand. These are interrelated phenomena. For example, changes in emissions from generation will not be cheap, and they will drive up the wholesale price of electricity. That price increase, in turn, will incentivize efficiency improvements and behavioral changes to consume less electricity.

Figure 5 presents the range of projected wholesale electricity price increases on a US annual average basis after accounting for all of the combined effects in their most cost-effective combination. The increases are substantial, including a 36% to 65% increase in those prices by 2015 alone. They continue to rise thereafter, reaching the range of an 80% to 125% increase by 2050. This occurs despite extensive technological advancements and efficiency enhancements. These estimates do not reflect any of the volatility in allowance or natural gas prices that can be expected, particularly in the initial years of the policy.

Figure 6 portrays the extent to which our analyses project electricity growth to moderate. The projected "business as usual" (BAU) growth in US electricity demand is shown as a range by the pink (i.e., upper two) lines (there is a range because our scenarios used different BAU growth paths). The range between the blue (i.e., lower two) lines shows demand after consideration of price-induced (and policy-induced) demand changes. These demand changes are on the order of 30% from BAU, and nearly levelize electricity demand growth. They do not occur costlessly. This degree of demand reduction can only occur *because* of the electricity price increases shown in Figure 5. These declines are, in part, induced by the higher cost of electricity, which makes

Figure 5. Projected Percentage Change in Wholesale Electricity Prices (Relative to "BAU")

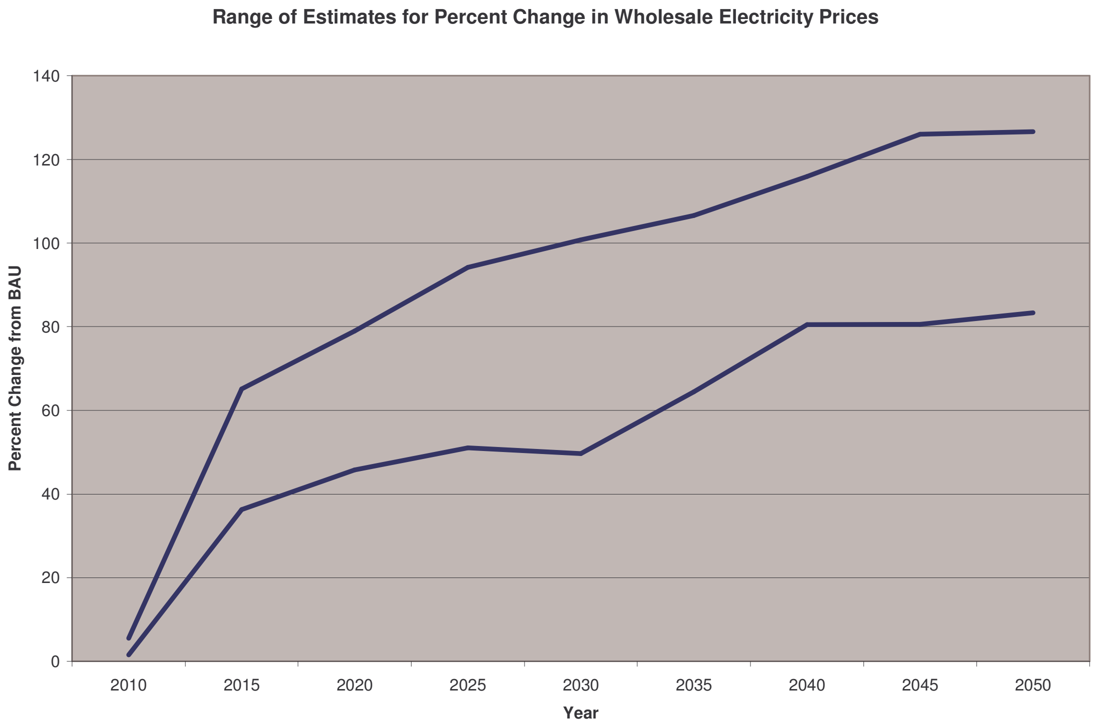
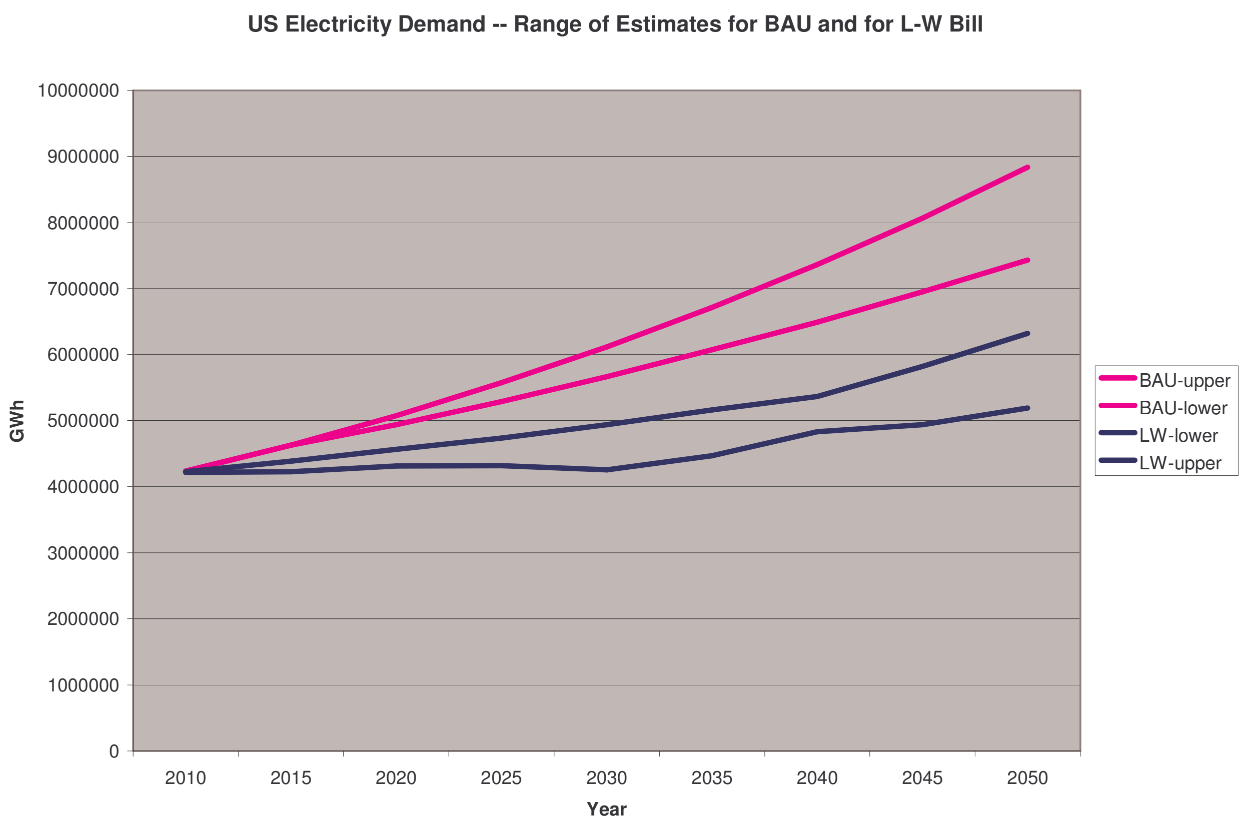


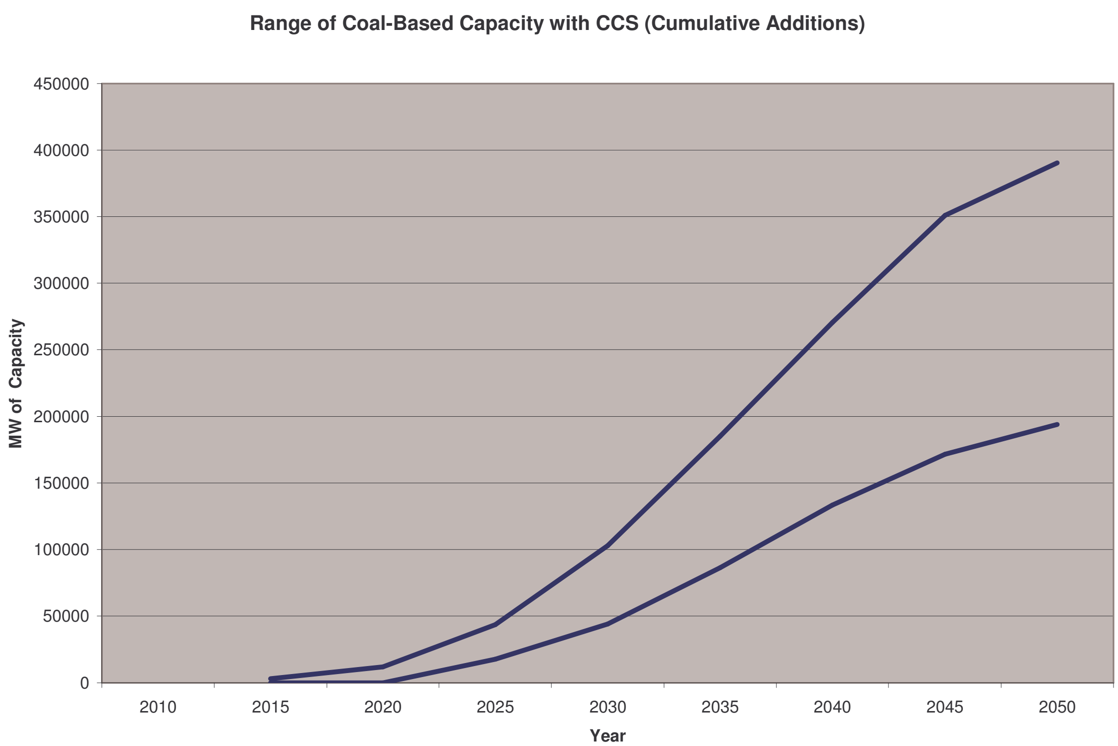
Figure 6. Electricity Demand with S.2191 and without a CO2 Limit



technological and behavioral changes in consumption a cost-effective choice. However, to some degree, these declines also reflect reductions in the productive output of the US economy, which is what I meant by the term "policy-induced" demand reduction. To some extent the latter declines may reflect mere leakage, which I discuss in the next section of my testimony.

Demand reduction, although large, contributes a relatively small share of the electric sector's emissions reductions. In the short-run, the major response is a rapid and large increase in the use of natural gas. In the longer-run, new technology plays the major role. Figure 7 shows the amount of CCS capacity that is assumed to be possible to install over time in our set of scenarios. Although not yet commercially available, our scenarios allow between 200 GW and over 400 GW of this technology to be installed by 2030. These are highly uncertain assumptions because there has been very little done yet in terms of technical feasibility studies to suggest realistic expectations for constructing new and replacement generation on the rapid timescales implied by this type of policy. The projected uptake of this allowed amount is usually at its maximal allowed levels.[6] To put these quantities into context, the current installed capacity of coal-fired generation in the US is about 300 GW. Thus, these scenarios allow the entire existing coal-fired asset base to be effectively replaced with CCS. (There are also very large amounts of zero-emitting renewables and nuclear generation that are available – and adopted – in these scenarios.)

Figure 7. Rates of Uptake of Advanced Coal-Based Generation with CCS



[6] Exceptions have occurred in the later years for scenarios with the largest allowed amounts of CCS combined with the lowest BAU demand forecast. Even in those cases, the projected use is at the maximum assumed to be possible in the mid-years, and very near the maximum even in the later years.

A notable element of Figure 7 relates to the *timing* of this large potential for future CCS installations. Although the scenarios assume that we can effectively replace our existing fossil fueled fleet with an equivalent capacity that has very low emissions (due to the CCS), this cannot be done in the near-term. Almost no CCS capacity can be realistically expected to help meet S.2191 targets in 2012-2015. Even by 2025, the quantity that can realistically be brought into the generating system is very small compared to the ultimate potential. In brief, the emissions targets of S.2191 are far ahead of the time curve of availability of the most critical technologies for achieving large emissions reductions. (We see similar temporal constraints on the low-carbon vehicle fueling options.)

With the timing of the target stringencies so far ahead of the ability of advanced technologies to respond, the only option of the electricity sector to meet the limits of S.2191 is a large shift from coal to natural gas generation during 2012 through 2030, and then an equally large shift back in the years from 2030 through 2050. The magnitude of these cycles is visible in Figures 8 and 9.

The projected cycle in coal and gas demands by the electricity sector will imply many types of costs and transitional issues not apparent in the model results. Huge changes in energy supply infrastructure will have to occur to enable both the first phase of the cycle (through 2030) and then again for the later phase of the cycle (after 2030). This cycle can be avoided altogether by better aligning the timing of the emissions targets with the availability of the advanced technologies that are expected to represent the long-run solution to greenhouse gas emissions. Doing so would also eliminate the near-term shocks to energy and electricity prices (such as evident in Figures 4 and 5), and allow a more gradual increase to the ultimately high prices that are necessary to reduce emissions to levels far below current emissions. Given that climate change risks are a long-term, cumulative phenomenon and not a near-term acute concern, true policy cost-effectiveness will come from a policy that allows a more gradual and steady transition to a low-carbon economy.

LEAKAGE: A CONCERN NOT FULLY ADDRESSED IN THE MODEL ANALYSIS

Some domestic companies whose products compete in international markets are likely to be driven out of business no matter what allocation they receive.

A generous allocation could increase the shareholder value of a company that is unable to increase its prices due to competition in international markets (i.e., a "trade exposed" industry). However, it will do this in a perverse way that policymakers need to be aware of. As the price of allowances rises, a company that cannot raise its product prices will experience falling margins. If that company is also granted free allocations, it can use them to offset some of the costs, and thus maintain profitability. However, this will only be true for a range of lower allowance prices. At some allowance price point, however, the profit margins will be negative and the company will cease production. There will be premature retirement of the existing productive assets in our trade-exposed sector, and reductions in the economic activities associated with those sectors. Given that the cause of the closures is international competition, these lost US manufacturing activities would be replaced by foreign manufacturing: global emissions will not fall but the US economy will still pay the price.

Figure 8. Cycle of Coal Demand by Electricity Sector due to S.2191 Targets

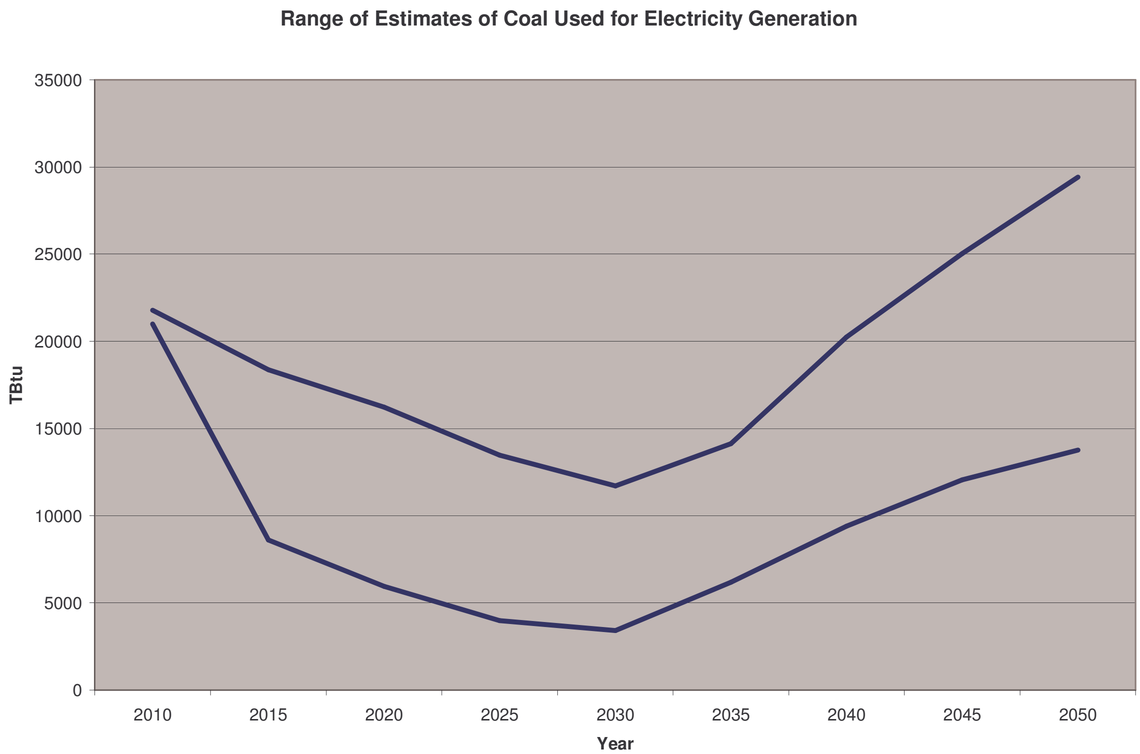
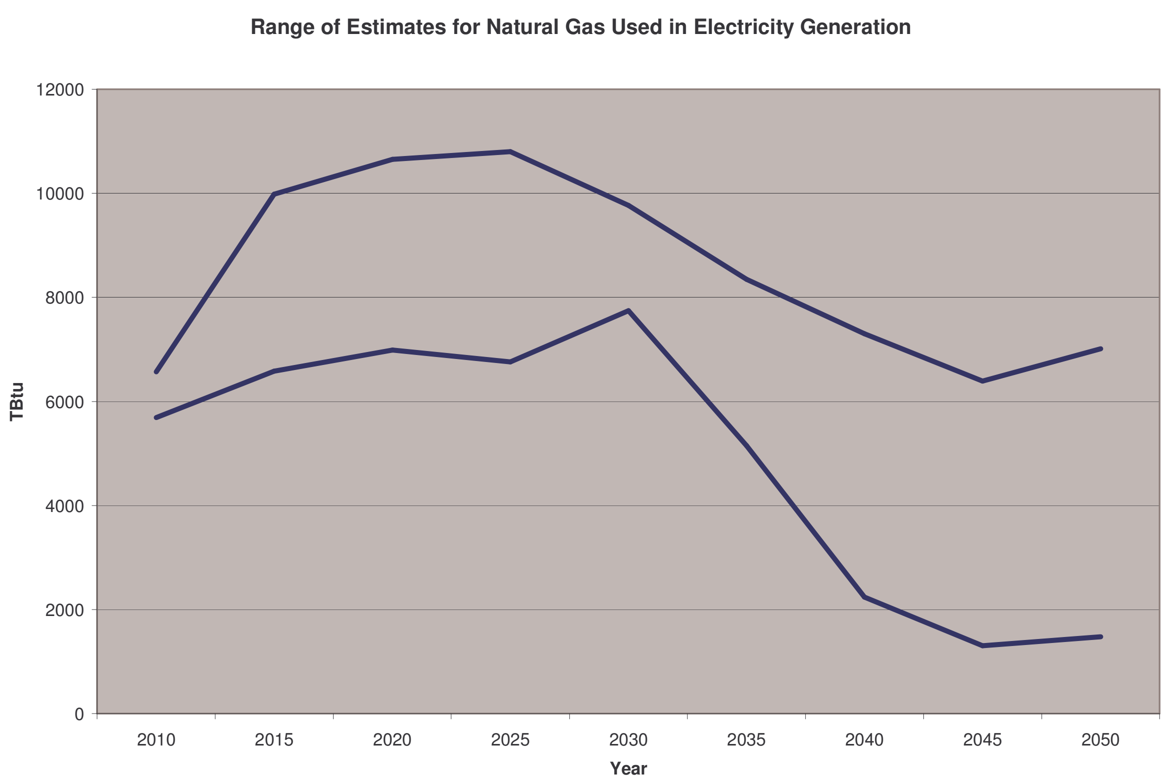


Figure 9. Cycle of Natural Gas Demand by Electricity Sector due to S.2191 Targets



This perverse outcome of climate policy is called “leakage” because the policy is rendered ineffective environmentally when it causes emissions to “leak” across national borders. Emissions from any part of the globe have comparable impacts on climate risks, as they all first accumulate together in the global atmosphere to have their combined and joint effect on the global greenhouse effect. On the one hand, this fact offers important flexibility to reduce emissions anywhere in the globe that has cost-effective opportunities to do so, and not to confine domestic efforts to actions within US borders. On the other hand, it also means that any GHG cap we impose domestically, and its attending domestic reductions, may be undermined by offsetting emissions increases in nations that do not have comparable caps on their own economies. Large sums of money could be spent with no actual global environmental benefit. US economic output and jobs leak to other countries as well.

Leakage has often been talked about in very general terms. Estimates of leakage due to a US domestic policy are suggested in the range of about 10-15%, meaning that for every 10 tons that is reduced in the US, 1 ton is just emitted elsewhere in the world. This may sound like a relatively small price to pay in order to get a net 9 tons of reduction from US action. The difficulty with this view, however, is that leakage is not a phenomenon that applies to every ton of emissions reduction. Instead, there may be almost no leakage associated with controls on emissions that are not trade-exposed (e.g., personal and commercial transportation, electricity generation, and services), but nearly 100% leakage associated with controls on emissions in sectors that *are* trade-exposed (e.g., many of the energy-intensive manufacturing processes such as cement, iron and steel, chemicals, transportation equipment manufacturing, textiles, etc.) Concentrated economic impacts on specific sectors that offer no benefit in terms of global emissions reduction make no sense as a matter of policy design.

The potential severity of the impacts to trade-exposed industries appears not yet fully appreciated by policy analysts or policymakers. Most of the attention on estimating climate policy impacts has been focused on transportation and electricity generation, which are among the least concerned with potential leakage. The potential plight of the trade-exposed industries has been mostly thought to be something that could be dealt with through compensating allocations. While that might solve the concerns of some of the shareholders of those businesses, policymakers should closely examine whether they are prepared to face the economic impacts of reduced exports, increased imports, and losses of domestic output of many important elements of the US manufacturing base.

Policymakers should focus on how to limit US emissions without creating leakage.

There are two ways to mitigate leakage without exempting trade-exposed sectors from an emissions cap:

1. The first is to impose domestic emissions limits only as part of a global agreement among all nations that compete with our products, or which might start to compete once a policy offers them a greater cost advantage than they have now. Clearly, the present policy proposals in the Congress would not accomplish this.

2. The second is to find ways to remove the competitive advantages of competitors at our borders, through "border tax adjustments." Border tax adjustments are allowed only under very special circumstances under the rules of the World Trade Organization (WTO).

The legality of obtaining effective border tax adjustments in the case of a cap-and-trade system is quite questionable at present.[7] Title VI of S.2191 represents an attempt to construct a system of border tax adjustments in a way that would be WTO-compliant, but it appears to have dubious chances of success in limiting leakage due to a cap-and-trade proposal. Title VI contains a complex set of provisions, each aimed at addressing one of several hurdles that would be faced in order to achieve the ultimate goal of equalizing costs of imports at the US border in a WTO-compliant manner. Each of these steps -- believed to be required to satisfy international law -- would be open to legal challenge, leaving multiple potential ways that the approach in Title VI could fail to provide the intended protection from leakage. Most critical in my mind, however, is that these many steps require time to accomplish. As embodied in S.2191, the imposition of leakage protection might not be possible until 2019. Given that the cap in this Bill would start in 2012, this would imply up to seven years during which US trade-exposed manufacturers would be facing competitive pressures, eroded ability to profitably continue in business, and experiencing leakage. Delays of this sort in obtaining that coverage are not acceptable for the businesses that face rapidly responding markets.

The method of S.2191 in Title VI for obtaining WTO-compliant leakage protection was crafted to work with a cap-and-trade form of proposal. Interestingly, the prospects of successfully and immediately implementing border tax adjustments are considered to be much greater in the case of a greenhouse gas tax than in the case of cap-and-trade.[8] If a carbon tax would provide better prospects for an immediate and WTO-compliant border tax adjustment, perhaps we should consider applying this type of approach for industries exposed to leakage through international competition, so that they at least can have the protection from leakage, even while other less vulnerable sectors could be in a cap-and-trade scheme if they choose. This might be especially useful to consider for certain commodities for which a heavy reliance on imported supply might be a strategic concern for the US. Those having a hand in creating a climate policy for the US should become much more familiar with the intricacies of WTO rules, and the likelihood of successfully creating immediate and durable protection from leakage under different types of greenhouse gas policy designs. This needs to be sorted out *before* and not after a greenhouse gas policy is enacted.

In the absence of a clear mechanism for preventing leakage with a cap-and-trade system, the only alternative for keeping economic impacts within acceptable bounds is to place a ceiling on the cost of allowances.

The higher the price of permits under the domestic cap, the more serious "leakage" is likely to be if there are no border tax adjustments in place. Thus, potential for leakage provides an important reason for directly ensuring that the price of permits that may occur under a domestic GHG cap-and-trade program will remain relatively low. The only way to design a domestic cap-and-trade program to address this international competitiveness risk is simply to keep the carbon price low enough that such losses remain within acceptable bounds. This, naturally, limits the amount of domestic

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[7] J. Pauwelyn, *U.S. Federal Climate Policy and Competitiveness Concerns: The Limits and Options of International Trade Law*, Nicholas Institute for Environmental Policy Solutions Working Paper NI WP 07-02, April 2007.
[8] *Ibid.*

emissions reductions that will be achieved as well. Until international competitiveness issues are resolved (either through coordinated action or a system of border tax adjustments) ambitions to make significant reductions through any domestic cap-and-trade program will be thwarted, or else highly disruptive to key parts of our economy. This also implies that any domestic cap-and-trade program that *is* implemented in advance of internationally coordinated efforts should be designed with clearly defined permit price caps.

PRICE UNCERTAINTY AND VOLATILITY: ANOTHER CONCERN NOT ADDRESSED IN THE MODEL ANALYSIS

An allowance price ceiling has important additional merits for businesses and government.

Prices in all previous and existing cap-and-trade programs have exhibited substantial volatility, and this can be expected of GHGs as well.[9] Price volatility, however, is likely to have much greater generalized economic impacts with a CO_2 cap than for caps on SO_2 and NO_x. CO_2 is a chemical that is an essential product during the extraction of energy from any fossil fuel. As long as fossil fuels are a key element of our energy system (which they are now, and will remain for many years even under very stringent caps), any change in the price placed on GHG emissions will alter the cost of doing business throughout the economy. This is because all parts of the economy require use of energy to one degree or another.

In contrast, under the Title IV SO_2 cap, a fluctuating SO_2 permit price would only affect emissions from coal-fired electricity generation. In deregulated electricity markets, coal-fired electricity does not always affect the wholesale price of electricity, and even significant fluctuations in SO_2 permit prices might have almost no effect on electricity prices. Even in regulated electricity markets, the impact of the SO_2 price on the cost of all electricity generation would be diluted by the unaffected costs of all other sources of generation before it reached customers. Also in contrast to an economy-wide GHG cap, no other sources of energy in the economy are affected at all by SO_2 price changes. Finally, under the Title IV SO_2 cap, price variations during the past year that range from \$400/ton to \$1500/ton (the range observed in the past year under Title IV) have a modest effect on the majority of coal-fired units that are already either scrubbed or burning low-sulfur coal. Such units might see the cost adder due to its SO_2 emissions vary between 7% and 26% of its base operating cost,[10] and (as noted) the impact on consumer's cost of electricity would be much smaller, if anything.

Variation of CO_2 prices such as that observed in the EU ETS market over the past two years (approximately \$0/ton to \$35/ton) would cause *all* coal-fired units to see additional costs varying between about 10% and 175% of their base operating costs. Further, even gas-fired units would

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[9] Some have argued that banking reduces price volatility. While it may reduce it, it certainly does not eliminate it. For example, the Title IV SO_2 market has experienced high volatility over the past two years, even though it has a large bank already in place. During 2005, SO_2 permit prices rose from about \$600/ton to above \$1600/ton, then plummeted to below \$400/ton by the beginning of 2007. Additionally, banking offers little price stability at all during the start up of a new cap, simply because no bank yet exists, and this initial-period volatility can be very large if the first-period cap requires a substantial amount of reduction and/or has a relatively brief regulatory lead time. The experience of the first year in the NO_x cap of the Ozone Transport Region of the northeastern U.S. is a classic example.

[10] By "base" operating cost, I mean the cost of generating a unit of electricity before accounting for the emissions price. The majority of this cost is the cost of the fuel.

experience absolute cost increases equal to about half those of the coal-fired units.[11] Since gas-fired units do frequently set the wholesale market price of electricity, consumer electricity prices would also vary markedly with the price of GHG permits. Retrofits would not be available to attenuate these costs (at least, not until even higher permit price levels would be achieved and *sustained* at those levels.) At the same time, all other key energy demands in the economy (e.g., for transportation, industrial process heat, building heating and air conditioning, etc.) would also experience similar fluctuations with varying GHG permit prices. Clearly, the effect on the economy could be disruptive.

These are not just theoretical calculations. The EU's statistics bureau, Eurostat, reports that electricity prices rose significantly throughout the EU in 2005. Household rates rose by 5% *on average* over all 25 EU countries, and industrial rates rose by 16% on average.[12] The high prices of GHG permits under the EU ETS during that period is widely viewed as having contributed to this price increase, and indeed, wholesale electricity prices have fluctuated in step with the wide swings in ETS permit prices. It is not clear yet how or whether the wide variations in permit prices may begin to contribute to the variation in economic activity. However, it should also be noted that the EU ETS does not cover all sources of GHGs, or even a majority of sources of CO_2 emissions in the EU. (This may dampen the impacts of CO_2 permit price volatility on the EU economy, but is also a widely observed flaw in that cap-and-trade system's potential to produce sufficient cuts in GHG emissions necessary for the EU to meet its GHG targets.)

To sum up, price uncertainty and price volatility will impose impacts in the case of GHG emissions limits that are completely different in scale and scope from those under previous emissions trading programs. Their potential to increase variability in overall economic activity thus should be viewed as a core concern in designing a GHG cap-and-trade program. At the same time, the nature of climate change risks associated with GHG emissions is such that it is possible to design price-stability into a GHG cap-and-trade program without undermining its environmental effectiveness. In the case of a stock pollutant such as greenhouse gases, there is no need to absorb high costs in return for great specificity in achieving each year's emissions cap.[13] Economists widely agree that the cost to businesses of managing the price uncertainty of a hard cap is not worth the greater certainty on what greenhouse gas emissions will be from year to year.

Businesses clearly prefer having reliable allowance price expectations, but even governments would probably prefer some stability in the year to year revenue streams from an auction. For example, would large variability and uncertainty in allowance auction revenues be of any use if those revenues are intended to fund important technology-related projects that have long-term funding needs? Even if the revenues would simply be rebated to citizens, would either the government or the citizens find any value in such uncertainty in the size of the rebate checks?

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[11] However, the percentage increase in the base operating cost would be much smaller (i.e., about 30% compared to 175%) because natural gas is so much more expensive than coal.
[12] Eurostat, "News Release – July 14, 2006" (Revised version 93/2006), available at http:/ec.europa.eu/eurostat
[13] Richard G. Newell and William A. Pizer 2003, "Regulating Stock Externalities Under Uncertainty," *Journal of Environmental Economics and Management,* Vol. 45, pp. 416-432.

A Price Ceiling Is the Only Approach that Will Offer the Requisite Degree of Price Certainty and Stability.

There are various ways to provide much greater price certainty under a cap-and-trade program, although none have been used in any trading programs to date. One of the simplest concepts that has gained substantial attention for GHGs has been called a "safety valve." Unfortunately, this term has begun to be used loosely (e.g., under the rules of the Regional Greenhouse Gas Initiative, and in California's AB32 program) for a variety of mechanisms that do not actually provide the price certainty originally intended. To be quite specific, the cap-and-trade program mechanism that provides the requisite price cap is one where the government offers to issue any number of additional permits to regulated companies at a pre-specified and fixed price per permit. This price is set low enough that it is not considered punitive, but rather as an assurance by the government that it would not consider control costs above that level to be desirable as a normal course of events.[14] This is the mechanism that has been incorporated into the bill of Senators Bingaman and Specter.

Because regulated entities know that they need not ever pay more for a permit than the established safety valve price, it functions as a price ceiling. No company would ever pay more to purchase a regular permit in the emissions market if it knows that it can always obtain sufficient permits at that price from the government, if necessary. Permit prices may fluctuate at levels below the safety valve price, but by judicious selection of an appropriate safety valve price, policy makers can ensure that these variations would not rise to a level that might be viewed as potentially harmful to the economy at large. If the safety valve price is hit on an occasional basis under a cap, then the goal of achieving long-term reductions in emissions is not harmed, given that the primary environmental risk of GHG emissions is a long-term, cumulative one. If the safety valve price is hit on a perpetual basis, this suggests an important need for policy makers to consider how we should address the evidence that meeting targets that are more difficult than hoped; however, this policy deliberation will be possible without the urgent need to throw "band-aid" solutions onto the cap-and-trade program, and with concrete evidence of the degree of economic pain that is associated with the initially-established maximum permit price. A higher price might then be deemed acceptable, but if not, the safety valve will have helped us avoid the greater pain of learning that fact through a hard cap approach.
A final advantage of a price ceiling provision is that it will limit the potential for gaming and other concerns with market manipulation that are often expressed for cap-and-trade schemes. The possibility of limiting risks of unacceptably high policy costs, providing planning certainty, eliminating wasteful price volatility, *and* mitigating concerns with allowance market manipulations ought to seem like a powerful argument in favor of a price ceiling provision.

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[14] Outside of the U.S., further confusion about the notion of a "safety valve" has been created by application of this term to the traditional notion of a penalty for noncompliance. The EU ETS has a penalty for noncompliance that is €40/ton CO_2 in Phase I and will be €100/ton in Phase II, starting in 2008. This is often described as a price cap, but its very high level relative to the price at which the cap is expected to be met makes it extremely ineffective. Further, its role as a penalty rather than as an additional compliance mechanism clearly would undermine the willingness of companies to resort to its use for planning purposes. The same confusion of penalty and safety valve appeared in the proposal for an Australian emissions trading scheme released in 2007 by Australia's National Emissions Trading Taskforce. The notion of a "safety valve" should be clearly separated from the role of a noncompliance penalty, with the former being set at a price that is considered an acceptable level of policy implementation cost, and the latter being set at a much higher level that is considered "punitive" and not acceptable as an indicator of the cost of meeting the policy goals.

The Carbon Market Efficiency Board of S.2191 Will Not Provide Price Certainty or Stability.

Aversion to the idea of a price ceiling has been widespread among parties that prefer hard caps at any cost over a long-run policy that offers price certainty in exchange for some flexibility in year to year emissions outcomes. Recently, a proposal for a "Carbon Market Efficiency Board" (CMEB) was released that was supposed to offer an alternative to the price ceiling approach.[15] This concept has been incorporated into S.2191 as Title II.F. Title II.F would provide no cost certainty at all. In fact, the white paper for the CMEB proposal that Title II.F follows explicitly states that it does not wish to diminish allowance price volatility: "The cost relieve measures are not intended to relieve brief price spikes that are part of normal, healthy market volatility."[16] The proposal goes on to assert that " 'volatility' in price is expected and even desirable."[17] As I have noted above, volatility creates unnecessary planning and management costs to businesses, and should be eliminated if possible without harming one's objectives for reducing emissions within acceptable cost bounds. This is entirely possible in the case of a market that is entirely the result of regulation, such as an allowance market. The CMEB proposal does not meet the objectives of providing price certainty or policy cost containment.

CONCLUSION

There is no question that achieving significant reductions in greenhouse gas emissions will be very costly, and it is therefore important to strive to minimize those costs. The design of the program matters, and mitigating the ranges of costs I have estimated for S.2191 will require taking care to incorporate several modifications to the present Bill. The most important attributes missing in S.2191 are:

- An approach that ensures policy costs will be held to a level considered acceptable to US citizens.
- A cap stringency that is timed to match the availability of new, low-carbon technologies.
- A policy that offers businesses price certainty for planning major new investments in new technologies (e.g., in the form of a price ceiling).
- A policy that protects against leakage of emissions to economically competing nations.
- A supportive set of policies that provide effective incentives for research and development on breakthroughs in technologies that produce low-carbon energy.
- Provisions in the policy to limit the costs that it will impose on the economy overall if emissions reductions turn out to be more expensive than considered acceptable.
- A policy that will deliver even larger emissions reductions if the targets turn out to be less expensive to achieve than is considered acceptable.

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[15] "Cost Containment for the Carbon Market: A Proposal," developed in consultation with the Nicholas Institute of Environmental Policy Solutions, Duke University, July 24, 2007. Available: http://www.nicholas.duke.edu/institute/carboncosts/carboncosts.pdf.
[16] *Ibid*., p. 3.
[17] *Ibid*., p. 7.

It may be wise for policymakers to take time to consider more closely alternatives to the cap-and-trade approach for greenhouse gases. Cap-and-trade is not the only form of market-based policy option, and others may be more able to offer the above list of attributes, and thus be better suited for meeting the challenge of reducing greenhouse gases to levels that are being proposed without excessive damages to our economy.